REMARKS

1. THE 35 U.S.C. § 112 REJECTION, 1ST PARAGRAPH REJECTION

Claims 47, 49 and 60 were rejected under 35 U.S.C. § 112, first paragraph, as failing to comply with the written description requirement. Specifically, the Examiner states that the "number of system parameters is larger than a number of system equations" is not described in the original disclosure.

Applicant has amended claims 47, 49 and 60 to recite "a number of *stiffness parameters* is larger than a number of system equations". In determining whether a written description issue exists, the fundamental factual inquiry is whether the specification conveys with reasonably clarity to those skilled in the art that, as of the filing date sought, applicant was in possession of the invention as now claimed. *Vas-Cath, Inc. v. Mahurkar*, 935 F.2d 1555, 1563-64 (Fed. Cir. 1991). It is respectfully submitted that the specification conveys with reasonably clarity to those skilled in the art that, as of the filing date sought, applicant was in possession of the invention as now recited in claims 47, 49 and 60. By way of example, par. [0130] of applicant's specification states that the system equations in Eqs. (5) and (6) involves $n_\lambda + n_\Phi N_m$ scalar equations with m unknowns, which are, in general determinate, if $n_\lambda + n_\Phi N_m = m$, under-determined if $n_\lambda + n_\Phi N_m < m$, and over-determined if $n_\lambda + n_\Phi N_m > m$. A system of linear equations is considered over-determined if there are more equations than unknowns, whereas an under-determined system of linear equations has more unknowns than equations (see, e.g., par. [0188] describing a scenario with a severely underdetermined system).

Accordingly, reconsideration and withdrawal of this 35 U.S.C. § 112, 1st paragraph rejection is respectfully requested.

2. The 35 U.S.C. § 112 Rejection, 2ND Paragraph Rejection

Claims 47-54, 60 and 61 were rejected under 35 U.S.C. § 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention. The Examiner alleges that the system parameters and the system equations are not defined and expresses confusion as to which parameters are system parameters and which equations are system equations. As noted above, claims 47, 49 and 60 have been amended to recite "stiffness parameters," rather than "system parmeters," which is believed to itself obviate the Examiner's rejection under 35 U.S.C. § 112, 2^{nd} paragraph. Nevertheless, additional commentary is provided below to assist the Examiner's understanding of the Applicant's disclosure and claims.

A. Claims 47, 49 and 60 Are Not Indefinite

The Examiner alleges that, as to claims 47, 49 and 60, the first order eigenvalue sensitivity analysis is not defined. This rejection is respectfully traversed.

Definiteness of claim language must be analyzed in light of the content of the application disclosure, the teachings of the prior art, and the claim interpretation that would be given by one of ordinary skill in the art at the time the invention was made. *See, e.g., In re Moore*, 439 F.2d 1232, 1235; 169 USPQ 236, 238 (CCPA 1971).

The essential inquiry in an indefiniteness analysis is whether the claims set out and circumscribe a particular subject matter with a reasonable degree of clarity.

As disclosed, the system and method may include a multiple-parameter, general order perturbation method, in which the changes in the stiffness parameters are used as the perturbation parameters (*see, e.g.*, par. [0067]). By equating the coefficients of like-order terms involving the same perturbation parameters in the normalization relations of eigenvectors and the eigenvalue problem, the perturbation problem solutions of all orders may be derived, and the

sensitivities of all eigenparameters may be obtained. *Id.* (emphasis added). The perturbation method may be used in an iterative manner with an optimization method to identify the stiffness parameters of structures. *Id.* By way of example, Equation (5) shows a scalar equation providing a ***first order*** eigenvalue sensitivity analysis (utilizing the ***first order*** eigenvalue $\lambda^{k}_{(1)i}$) and equation (17) provides one result of a ***first order*** eigenvalue sensitivity analysis.

Accordingly, when the claim language in question is analyzed in light of the content of the application disclosure, the teachings of the prior art, <u>and</u> the claim interpretation that would be given by one of ordinary skill in the art at the time the invention was made, Applicants submit that the first order eigenvalue sensitivity analysis is <u>not</u> indefinite and, quite to the contrary, is well defined in Applicant's specification.

B. CLAIMS 47, 49 AND 60 DO NOT OMIT ESSENTIAL COOPERATIVE RELATIONSHIPS OF ELEMENTS

Claims 47, 49 and 60 were also rejected as being incomplete for omitting essential structural cooperative relationships of elements. The Examiner particularly alleged that there were no relationships between the system parameters and equations and other claimed elements.

As noted above, claims 47, 49 and 60 have been amended to recite "a number of *stiffness parameters* is larger than a number of system equations". Accordingly, it is submitted that the Examiner's amendment is overcome as the claim recites essential structural cooperative relationships of elements. For example, as to claim 47, there is recited "a stiffness parameter unit for . . . determining the stiffness parameters of said structure" and "an iterative processing unit that determines said stiffness parameters using a first order eigenvalue sensitivity analysis and one of the generalized inverse method, gradient method, or quasi-Newton method, wherein a number of *stiffness parameters* is larger than a number of system equations."

Accordingly, when the claim language in question is analyzed in light of the content of the application disclosure, the teachings of the prior art, and the claim interpretation that would be given by one of ordinary skill in the art at the time the invention was made, Applicants respectfully submit that claims 47, 49 and 60 are not incomplete owing to omitted essential structural cooperative relationships of elements.

C. CLAIMS 48, 50 AND 61 ARE NOT INDEFINITE

The Examiner alleges that, as to claims 48, 50 and 61, the second or higher order perturbation process is not defined. This rejection is respectfully traversed.

Claim 48 recites "a stiffness parameter unit for receiving said vibration information, determining natural frequency data of said structure, and determining the stiffness parameters of said structure using said natural frequency data, wherein said stiffness parameter unit comprises an iterative processing unit that determines said stiffness parameters *using a second or higher order perturbation process*." (emphasis added). Claim 50 recites "a stiffness parameter unit for receiving said vibration information and determining said stiffness parameters with an iterative processing unit; wherein said stiffness parameter unit comprises an iterative processing unit that determines said stiffness parameters *using a second or higher order perturbation process*." (emphasis added). Claim 61 recites "a stiffness parameter unit for receiving said vibration information, determining mode shape information, and determining the stiffness parameters of said structure using said mode shape information; wherein said stiffness parameter unit comprises an iterative processing unit that determines said stiffness parameters *using a second or higher order perturbation process*." (emphasis added).

Perturbation theory comprises mathematical methods that are used to find an approximate solution to a problem which cannot be solved exactly, by starting from the exact solution of a related problem. Perturbation theory is applicable if the problem at hand can be

formulated by adding a "small" term to the mathematical description of the exactly solvable problem. The principle of perturbation theory is to study dynamical systems that are small perturbations of "simple" systems. Eigenvalue perturbation is a perturbation approach to finding eigenvalues and eigenvectors of systems perturbed from one with known eigenvectors and eigenvalues, allowing determination of the sensitivity of the eigenvalues and eigenvectors with respect to changes in the system.

Similar to the above remarks directed to the first order eigenvalue sensitivity analysis, as to the second or higher order perturbation process par. [0065] of Applicant's specification describes that the stiffness parameter unit 103 may include an iterative processing unit 115 capable of determining stiffness parameters using a first order perturbation approach and the generalized inverse method and may further include an outer iterative processing unit 117 and an inner (nested) iterative processing unit 119 "which may operate using a first ***or higher order perturbation approach*** and a gradient or quasi-Newton method" (emphasis added). By equating the coefficients of like-order terms involving the same perturbation parameters in the normalization relations of eigenvectors and the eigenvalue problem, "the perturbation problem solutions ***of all orders may be derived***, and the sensitivities of all eigenparameters may be obtained" (see, e.g., par. [0067])(emphasis added). Equations (5) (a scalar equation) and (6) (a vector equation) respectively show second order terms of, second order eigenvalue $\lambda^{k}_{(2)ij}$ and second order eigenvector $z^{k}_{(2)ij}$, in which equations $\lambda^{k}_{(1)i}$, $\lambda^{k}_{(2)ij}$, . . . , and $\lambda^{k}_{(p)ij}$ are the coefficients of the first, second, . . . , "and **p-th order** ***perturbations*** for the eigenvalue and in which $z^{k}_{(1)i}$, $z^{k}_{(2)ij}$, . . . , and $z^{k}_{(p)ij}$ are the coefficient vectors of the first, second, . . . , and **p-th order** ***perturbations*** for the eigenvector" (see, e.g., par. [0076])(emphasis added). As noted therein, the numbers in the parentheses in the subscripts of the coefficients and coefficient vectors indicate the orders of the terms. Equations (5) and (6) show the full perturbations of the

eigenparameters to changes in stiffness parameters. Equation (7) then shows in the left hand portion, the result of a Taylor expansion ($p!\lambda^{k}_{(p)ij...t}$) of the partial derivative of the eigenvalue λ^k with respect to the stiffness parameters $\delta G_i\ \delta G_j...\delta G_t$ and shows in the right hand portion, the result of a Taylor expansion ($p!z^{k}_{(p)ij...t}$) of the partial derivative of the eigenvector z^k with respect to the stiffness parameters $\delta G_i\ \delta G_j...\delta G_t$.

Accordingly, when the claim language in question is analyzed in light of the content of the application disclosure, the teachings of the prior art, <u>and</u> the claim interpretation that would be given by one of ordinary skill in the art at the time the invention was made, Applicants submit that the recited second or higher order perturbation process is <u>not</u> indefinite and, quite to the contrary, is well defined in Applicant's specification.

D. Claim 51 Clarification

As to claim 51, the Examiner states that the outputted damage location on the structure should be based on the stiffness parameters. Applicant is, responsive to the Examiner's comment, amending herein claim 51 to recite "a damage information processor for receiving said stiffness parameters and outputting location of damage on said structure <u>based on said stiffness parameters</u>." Withdrawal of this rejection is requested.

3. THE 35 U.S.C. § 102(E) REJECTION OF CLAIMS 15-16

Claims 15-16 were rejected under 35 U.S.C. § 102(e) over Weiss (US 2003/0013541). Applicants respectfully submit that the Examiner's interpretation of Weiss is incorrect. Reconsideration and withdrawal of this rejection is respectfully requested.

As an initial matter, the amendments previously presented were acknowledged by the Examiner to overcome this rejection during the Examiner Interview held on July 16, 2008. It was believed during the Examiner interview that the Examiner appreciated why Weiss was not anticipatory of claims 15-16, as had been alleged and as is now being alleged. To reiterate that

which was believed to have been clearly communicated and understood to distinguish the claimed invention and disclosed concepts from Weiss, Applicants provide below for the Examiner's information explanatory information from the specification, including points presented during the Examiner Interview.

As noted during the Examiner Interview, FIG. 1A and associated description in the specification, show a system 100 for detecting structural damage according to one embodiment of the invention wherein a stiffness parameter unit 103 is provided to receive vibration information and provide natural frequency, mode shape data, or both natural frequency and mode shape data to detect the stiffness of a structure in question. FIG. 1A also shows that the stiffness parameter unit 103 may include an iterative processing unit 115 capable of determining stiffness parameters using a first order perturbation approach and the generalized inverse method. *See, e.g.*, par. [0065]. Stiffness parameter unit 103 may also or alternatively include an outer iterative processing unit 117 and an inner (nested) iterative processing unit 119 which may operate using a first order perturbation approach and a gradient or quasi-Newton method. *See, e.g.*, par. [0065]. The gradient method is described, for example, in pars. [0138]-[0144] and [0150]-[0155]. The quasi-Newton method is described, for example, in pars. [0145]-[0155].

FIG. 1B of Applicant's disclosure shows steps included in a method for detecting structural damage in accordance with aspects of the present concepts, including an initial step (1) measuring one or more eigenparameters, λ_d^k and Φ_d^k, which are then compared with estimated eigenparameters associated with the stiffness parameters, $G_i^{(0)}$ and the differences between the measured and estimated eigenparameters determined (2). These differences are then used in a sensitivity analysis to establish system equations (5) and (6) and an optimization method (e.g., gradient method, quasi-Newton method, etc.) is then used to find $G_i^{(w)}$ (see, e.g., par. [0134]-[0155]).

As to the recitations of the eigenvector sensitivity analysis or eigenvalue sensitivity analysis, Applicants disclose approaches to solving eigenvalues and eigenvectors of systems perturbed from a system with known eigenvectors and eigenvalues to determine the sensitivity of the eigenvalues and eigenvectors with respect to changes in the system (*see, e.g.*, pars. [0067], [0078], [0126], [0129]). One example of such methodology begins with par. [0069] of Applicant's disclosure. In an N degree-of-freedom, linear, time-invariant, self-adjoint system with distinct eigenvalues, the stiffness parameters of the undamaged structure are denoted by G_{hi} ($i = 1, 2, \ldots, m$), where m is the number of the stiffness parameters. The estimated stiffness parameters of the damaged structure before each iteration are denoted by G_i ($i = 1, 2, \ldots, m$), and its stiffness matrix, which depends linearly on G_i, is denoted by $K = K(G)$, where $G=[G_1, G_2, \ldots, G_m]^T$, where the superscript T denotes matrix transpose. The eigenvalue problem of the structure with stiffness parameters G_i is, as shown in Equation (1) ($K\Phi^k = \lambda^k M\Phi^k$) where M is the constant mass matrix, $\lambda^k = \lambda^k(G)$ and $\Phi^k = \Phi^k(G)$ ($k=1, 2, \ldots, N$) are the k-th eigenvalue and mass-normalized eigenvector respectively. The eigenvalue problem of the damaged structure is $K\Phi_d^k = \lambda_d^k M\Phi_d^k$) where $K_d = K(G_d)$ is the stiffness matrix with $G_{(d)} = [G_{d1}, G_{d2}, \ldots G_{dm}]^T$ and $\lambda_d^k = \lambda^k(G_d)$ and $\Phi_d^k = \Phi^k(G_d)$ (see, e.g., par. [0072]-[0073]). The k-th eigenvalue and mass-normalized eigenvector of the damaged structure is related to λ^k and Φ^k through equation (5) (see par. [0075]-[0076]), wherein the first order sensitivity analysis for the difference between λ^k and λ_d^k includes the summation, from $i = 1$ to m, the term $\lambda^k_{(1)i}\delta G_i$, where $\lambda^k_{(1)i}$ is the coefficient of the 1^{st} order perturbation for the eigenvalue, and wherein the first order sensitivity analysis for the difference between Φ^k and Φ_d^k includes the summation, from $i = 1$ to m, the term $z^k_{(1)i}\delta G_i$, where $z^k_{(1)i}$ is the coefficient vector of the 1^{st} order perturbation for the eigenvector.

As one example of the analysis for the under-determined system, the Examiner is kindly referred to the beam examples of pars. [0166] to [180] (*see also* FIGS. 7-11) and subsequent

numerical and experimental verification scenarios (pars. [0184] to [0194]; FIGS. 12-17) and simulations (pars. [0195] to [0203]; FIGS. 18-21). In scenario 1, for example, a 45 cm long aluminum test specimen was divided into 40 elements, each element having a length of 1.125 cm, and was machined on top and bottom surfaces to simulate damage at a lengthwise position of about 10-15 cm, as measured from the cantilevered end (*see* par. [0187]; FIG. 13). The machining corresponded to 56% of damage (or reduction of bending stiffness EI) along the length of five elements (from the 9th to the 13th element). As shown in FIG. 13, results were obtained with 2-5 frequencies. As is noted by the Applicants in Applicant's specification, the extent of damage detected is slightly lower than the actual extent because the predicted damage occurs at 2 more elements (the 7th and 8th elements) than the actual one arising from the solution of the severely underdetermined system equations (5 equations with 80 unknowns).

Turning to the substance of the rejection of claims 15-16, the Examiner alleges that Weiss discloses "a system (Fig. 19) for determining stiffness parameters of a structure . . . comprising . . . a sensor (1877) arranged to measure vibrations of a structure having a lengthwise much greater in magnitude than cross-sectional dimensional thereof (shaft 110's length versus cross-sectional dimensions, Fig. 11) and output to vibration information (paragraph 0116, lines 1-2) . . . a stiffness parameter unit (62) for receiving said vibration information (paragraph 0116, lines 1-3) . . . a damage information processor (61) for receiving said stiffness parameters and outputting damage information . . . comprising at least spatial damage information on said structure (symmetry/asymmetry data, paragraph 0160, lines 2-3, represents spatial damage information), said spatial damage information comprising a damage location along said lengthwise dimension (since the problem of asymmetry is along the length of the elongated member, paragraph 0160, lines 2-4)".

Par. [0160] of Weiss, in which the Examiner alleges is disclosed spatial damage information comprising "at least spatial damage information on said structure" and "spatial damage information comprising a damage location along said lengthwise dimension" states:

> While the invention has been described so far in terms of golf club shafts, it can be used to determine the symmetry/asymmetry, roundness, straightness and/or stiffness of any elongated member, including, but not limited to, baseball bats, billiard cues, arrows, fishing rods, or any structural member.

The Examiner appears to be misinterpreting Weiss's statement of determining the "symmetry/asymmetry" as representing spatial damage information along the lengthwise dimension under the belief that Weiss's teachings are directed to a "problem of asymmetry . . . along the length of the elongated member". Weiss's method can **only** give a global stiffness in the <u>circumferential</u> direction and **cannot** reveal anything about the stiffness <u>along the structure</u>.

Weiss does provide teachings relating to symmetry/asymmetry, but these teachings are limited to circumferential symmetry/asymmetry and <u>do not include</u> spatial damage information comprising a damage location along said lengthwise dimension of said structure. In par. [0003], Weiss frames the problem solved wherein, [w]hen a golfer swings a golf club, the shaft of the golf club bends or twists, especially during the downswing" and "[t]he direction the shaft bends or twists is dependent on how the golfer loads or accelerates the club, but the bending or twisting direction and magnitude also are dependent on the stiffness of the shaft." Weiss states further that "[i]f a shaft is soft, it will bend or twist more during a given downswing than if it is stiff" and that "[a]dditionally if a shaft exhibits different transverse stiffness in different planes--i.e., the stiffness, roundness and straightness of the shaft are not symmetric--the shaft will bend or twist differently depending upon in which plane (direction) it is loaded." (par. [0003]). Weiss states that "[i]nconsistent bending or twisting makes it more difficult for the golfer to reproduce the downswing shaft bending or twisting from club to club, thereby resulting in less consistent impact repeatability within the set" and that "[b]ecause any inconsistent bending or twisting due

to a*symmetric* shaft behavior . . . is substantially impossible for the golfer to correct with his or her swing, any reduction in the aforementioned oscillation immediately prior to impact will help the golfer improve his or her impact repeatability, thereby enhancing performance." (par. [0004]). Weiss discloses that "[i]nconsistent bending or twisting contributes to movements of the club head that would not be present if the shaft had been perfectly symmetric" and that "[g]olf club shaft manufacturers attempt to build shafts with symmetric stiffness to minimize inconsistent bending or twisting during the swing, but as a result of manufacturing limitations it is difficult to build a perfectly symmetric golf club shaft." Weiss further states that "it is sometimes said that a golf club shaft has a 'spine' whose orientation may be significant. . . . Therefore, substantially all golf club shafts exhibit some degree of asymmetry which results in some degree of inconsistent bending or twisting during the swing." (pars. [0006]-[0007]).

Weiss continues on to say that "[t]he asymmetry of golf club shafts can result from nonsymmetrical cross sections (shafts whose cross sections are not round or whose wall thicknesses are not uniform), shafts that are not straight, or shafts whose material properties vary around the circumference of the shaft cross section." (par. [0007]). Weiss's goal is to understand . . . asymmetric bending or twisting behavior and construct . . . golf clubs . . . to maximize consistency from club to club within a set and from set to set within a brand." *Id.*

Thus, Weiss relates to ***circumferential*** symmetry/asymmetry. This is only emphasized by FIG. 25, which is cited by the Examiner (the Examiner cites Weiss, FIG. 25 as disclosing "data for non-perfect shaft vs. data for perfect shaft displayed via 257, paragraph 0159, lines 18-22"). The Examiner is correct in that FIG. 25 shows data for non-perfect shaft vs. data for perfect shaft displayed via 257. However, the Examiner's interpretation of FIG. 25, as that of the remainder of Weiss, is incorrect. Par. [0159] shows the results of the "spine" or planar oscillation plane location measurements at 252, with two phase plots 253, 254 to show the shaft

vibration characteristics in the "logo-up" position and in the principal planar oscillation plane, respectively, as located. Plot 257 shows vibration frequency ***as a function of angular position***. In plot 257, the circular data points represent a "perfect" shaft in which the stiffness, and the frequency, ***is the same at all angles***, while the square data points show the frequency data for the shaft being measured. By way of example, Weiss describes in par. [0057] that "[t]he stiffness of the shaft can then be characterized by the value of k ***at each angle***" (emphasis added). Weiss continues on in par. [0058] to state that "***[a]t each angular position***, a load test can also be administered, by deflecting the shaft through a fixed distance, d, transverse to its longitudinal axis and measuring the restoring force, F, generated." (emphasis added). Continuing, Weiss states that "[f]rom the force, F, and the spring constant, k, determined above, one can determine the deviation, δ, which is a measure of the straightness of the shaft, from the relation $F/k=d+\delta$" and that "[t]he straightness of the shaft can then be characterized by the value of δ ***at each angle***." Thus, Weiss does **NOT** disclose or suggest "spatial damage information comprising a damage location along said lengthwise dimension," as alleged by the Examiner. Instead, Weiss discloses determination only of the "spine" of the club shaft – the angular position of the principal oscillation plane (*i.e.*, the angular orientation of shaft 10 in which, if the initial displacing force F were applied along that orientation, shaft 10 would oscillate substantially only along that orientation, with the tip tracing back and forth substantially along a line)(see, e.g., par. 0061; FIG. 4). For example, FIG. 21 shows out-of-plane displacement plotted in polar coordinates ***as a function of angle*** (every 10°) wherein dashed lines 211 occur at the cusps between the lobes (local minima of out-of-plane displacement) and represent the planar oscillation planes (*see also* par. [0085]). Weiss discloses that, ***at each angular position***, the vibration frequency of the shaft provides a measure of its stiffness. Weiss provides only a

GROSS measure of stiffness that is independent of axial length of the shaft and is unable to resolve a location of damage or a change in stiffness at a point along a length of the shaft.

Likewise, as to claim 16, Weiss does **NOT** disclose or suggest that, further to a damage information processor for receiving said stiffness parameters and outputting damage information comprising spatial damage information on said structure, said spatial damage information comprising a damage location along said lengthwise dimension of said structure, and outputting extent of damage information.

The factual determination of lack of novelty under 35 U.S.C. §102 requires the identical disclosure in a single reference of each element of a claimed invention such that the identically claimed invention is placed into the recognized possession of one having ordinary skill in the art. *Helifix Ltd. v. Blok-Lok, Ltd*, 208 F.3d 1339 (Fed. Cir. 2000). The Examiner has failed to discharge the burden of setting forth a *prima facie* case of anticipation and, moreover, Weiss fails to disclose each element of a claimed invention such that the identically claimed invention is placed into the recognized possession of one having ordinary skill in the art. Accordingly, Weiss ***fails*** to disclose (or suggest) under 35 U.S.C. § 102 the subject matter of claims 15-16. Withdrawal is requested.

4. THE 35 U.S.C. § 103(A) REJECTION OF CLAIMS 47, 49 AND 60

Claims 47, 49 and 60 were rejected under 35 U.S.C. § 103(a) over Weiss in view of Bennighof (US 7,188,039). Withdrawal of this rejection is respectfully requested.

Weiss is acknowledged not to disclose "a first order eigenvalue sensitivity analysis and one of the generalized inverse method, gradient method, or quasi-Newton method" (see Office Action, Page 7).

To make up for this deficiency, Bennighof is cited as disclosing "a first order eigenvalue sensitivity analysis (column 5, lines 63-66) and one of the generalized inverse method (column 4,

lines 5-12) for the purpose of determining structure" (see Office Action, Page 7). The Examiner concludes from those passages that, "[t]herefore, it would have been obvious . . . to provide Weiss et al. with the eigenvalue sensitivity analysis and inverse method as disclosed by Bennighof for the purpose of determining structure (column 6, lines 9-13)."

Although it is not clear what the Examiner means by "for the purpose of determining structure,"[1] it is clear that Bennighof fails to disclose an iterative processing unit that determines stiffness parameters using a first order eigenvalue sensitivity analysis <u>and</u> fails to disclose a generalized inverse method, as alleged.

As to the Examiner's first contention, col. 5, lines 63-66 of Bennighof states:

> "if the structural damping matrix *is not of low rank*, computing the eigenvalues and eigenvectors of the matrix which is formed from the modal or reduced stiffness"

(emphasis added). Bennighof described the "rank" in part in col. 1, wherein Bennighof states "[i]t is important to note that if the structures being modeled are automobiles, the matrix B may be of very low rank (e.g., less than about 50, including zero) *because B's rank is substantially equal to the number of viscous damping elements, which can include shock absorbers and engine mounts.*" (col. 1, lines 33-37)(emphasis added). Bennighof further states that "[i]f the matrix K_4, in Equation (1) is of relatively low rank (e.g., rank less than about 2000, including zero), forming the matrix C and solving the eigenvalue problem $C\Phi_C = \Phi_C\Lambda_C$ may become unnecessary (col. 4, lines 45-48). Thus, the passage cited by and relied upon by the Examiner states that if the structural damping matrix comprises a significant number of viscous damping

[1] The passage to which the Examiner cites, col. 6, lines 9-13, states that "[b]uilding on the principles illustrated above, many embodiments may be realized. For example, FIG. 1 is a flow diagram illustrating a method according to various embodiments. <u>*The method 111 may be used to solve an equation associated with a structure*</u>, such as a building or an automobile, of the form $\{-\omega^2 M_R + i\omega B R + [(1+i\gamma)K_R + i(K_{4R})]\}Y = F_R$. ω may be a time-harmonic excitation frequency, M_R may be a reduced form of a symmetric mass matrix M, B_R may be a reduced form of a viscous damping matrix B, and γ may be a scalar global structural damping coefficient. K_R may be a reduced form of a symmetric stiffness matrix K, K_{4R} may be a reduced form of a symmetric structural damping matrix K_4 representing local departures from γ, and F_R may be a reduced form of a matrix F including a plurality of load vectors acting on the structure." (emphasis added).

elements (i.e., not of a low rank), the eigenvalues and eigenvectors of the matrix formed from the modal or reduced stiffness is computed. Correspondingly, if the rank of B (the viscous damping matrix (see, e.g., col. 1, lines 30-31)) is low (e.g., an undamped system), then the eigenvalues and eigenvectors of the matrix formed from the modal or reduced stiffness would not be computed. The easiest way to find the inverse in this case is to use LU decomposition or other faster methods. In practice, it is seldom necessary to form the explicit inverse of a matrix and it is more efficient and more accurate to use the matrix division operator x = A\b to produce the solution using Gaussian elimination, without forming the inverse.

Col. 4, lines 5-12 of Bennighof states:

> The coefficient matrix (D+PQR) may be referred to as a "diagonal plus low rank" (DPLR) matrix, the modified frequency response problem (Equation (5)) may be referred to as the DPLR problem, and the solution matrix Z may be referred to as the DPLR solution. The inverse of the DPLR matrix is given by Equation (6):
>
> $$(D+PQR)^{-1}=D^{-1}-D^{-1}PQ^{1/2}(I+Q^{1/2}RD^{-1}PQ^{1/2})^{-1}Q^{1/2}RD^{-1}. \qquad (6)$$

However, col. 4, lines 5-12 does not disclose a generalized inverse method, as was alleged by the Examiner. Instead, Bennighof merely discloses the taking of an inverse of a square matrix (see, e.g., col. 3, lines 5-49). This is not the same as the "generalized inverse method." Moreover, claims 47, 49 and 60 relate to an underdetermined system wherein "a number of stiffness parameters is larger than a number of system equations". Accordingly, the associated matrix would not be a square matrix, but would instead include a different number of rows and columns. Bennighof relates to apparatus, systems, and methods for vibration analysis of various structures, including vehicles (see col. 1, lines 15-17). Bennighof particularly relates to addressing frequency response problem in automotive applications and, more generally, to "more efficiently determining the frequency response characteristics of damped structures,

including vehicles, such as automobiles, aircraft, ships, submarines, and spacecraft." (col. 2, lines 56-60).

As noted in *KSR Int'l Co. v. Teleflex Inc.*, "[a] factfinder should be aware, of course, of the distortion caused by hindsight bias and must be cautious of arguments reliant upon *ex post* reasoning." 127 S.Ct. 1727, 1741, 82 USPQ2d 1385, 1397 (2007); *See Graham* v. *John Deere Co. of Kansas City*, 383 U.S. 1, 36 (warning against a "temptation to read into the prior art the teachings of the invention in issue" and instructing courts to "'guard against slipping into the use of hindsight'" (*quoting Monroe Auto Equipment Co.* v. *Heckethorn Mfg. & Supply Co.*, 332 F.2d 406, 412 [141 USPQ 549] (CA6 1964))). Here, Applicant respectfully submits that the evidentiary basis proffered to support the combination of Bennighof with Weiss is lacking and fails to set a legally sufficient motivation for combination of Bennighof with Weiss. Broad conclusory statements, standing alone, are not "evidence". *McElmurry v. Arkansas Power & Light Co.*, 995 F.2d 1576, 1578 (Fed. Cir. 1993). In the rejection, the Examiner states merely that one of ordinary skill in the art at the time of the invention would have combined the disclosure of col. 5, lines 63-66 and col. 4, lines 5-12 of Bennighof with the disclosure of Weiss, purportedly "for the purpose of determining structure," whatever that is intended to mean. This allegation is drawn from a convincing line of reasoning based on established scientific principles or legal precedent. Instead, the Examiner's allegation is an unsupported assertion devoid of any context of factual predicate. Why would one of ordinary skill in the art be motivated to combine equations and processes specific to a frequency response problem and designed to determine the frequency response characteristics of <u>damped structures</u> (e.g., "automobiles, aircraft, ships, submarines, and spacecraft" (see col. 2, lines 55-60) comprising viscous dampers) to the system of Weiss, in which the stiffness of a golf club shaft is determined by a system for determining the planar oscillation plane(s) of the golf club shaft -- a system that does <u>not</u> include a viscous

damper? Stated differently, in Bennighof, B is the viscous damping matrix (see, e.g., col. 1, lines 30-31). Bennighof acknowledges that B's rank could theoretically be zero (see, e.g., 34-35). However, in such instance, according to the passage cited by the Examiner, eigenvectors of the matrix which is formed from the modal or reduced stiffness and structural damping matrices would not be calculated because the structural damping matrix would be of a low rank (i.e., a zero rank)(see, e.g., col. 5, lines 63-66). Moreover, if B were to have a zero rank, how would that affect equation (3) of Bennighof and the singular value decomposition shown in equation (4) – how would equations (5) and (6) showings relations of $\Phi_C^T \Phi_T^F$, cited by the Examiner, and, in view of such modification, what would this result then teach or suggest for a zero rank system? Still further, Bennighof is concerned with a frequency response function involving a **time-harmonic excitation frequency, ω** (see, e.g., Abstract; col. 1, lines 25-30; col. 6, lines 8-16), which is not relevant to the free vibration of Weiss. Weiss, in contrast with Bennighof, provides a dynamic test in which an impulse is applied to the golf club system "by deflecting tip 112 of golf club shaft 110 to side 120 of deflector arm 93 opposite side 930, as seen in FIG. 12, and then, preferably in a sudden motion, pivoting deflector arm 93 out of its erect position, allowing the restoring force in deflected golf club shaft 110 to provide a horizontal impulse to start tip 112 of golf club shaft 110 to begin vibrating, along with tip mass and sensor assembly 77, in the manner described above in connection with FIGS. 2-5." (see, e.g., par. [0082]). Weiss does not disclose or suggest an apparatus or system frequency response function involving a time-harmonic excitation frequency. Moreover, Weiss eschews a computational approach (i.e., teaches away from a computational approach), stating that "[a]lthough apparatus 60 could be made to implement the rigorous mathematics set forth above,[2] it has been

[2] It is to be noted that the alleged "rigorous mathematics" noted by Weiss is not the same as the mathematics disclosed by and claimed by Applicants in the instant case.

determined in practice that a simpler iterative process as described below achieves acceptable results at lower cost." (see par. [0067]).

Further, to underscore still additional aspects of the inappropriateness of the combination of Bennighof with Weiss, From a modeling standpoint, Weiss only uses a simple one degree of freedom (1-dof) analytical model while Bennighof models tens or hundreds of thousands of degrees of freedom, or higher, since (*e.g.*, Bennighof mentions matrices having a "relatively low rank" of 2000 (*see, e.g.*, col. 15, lines 10-12) and notes that the matrices M, B, K and K4 may comprise "*millions* of rows and columns" (col. 1, lines 48-50))(emphasis added). As Bennighof is particularly directed to vehicles, Bennighof is most likely near about 400,000 - 500,000 degrees of freedom (see, e.g., SD Tools, Vibration Software and Consulting, FEMLink 3.3, provided in the accompanying IDS Form PTO-1449; http://www.sdtools.com/femlink.html). The model proposed by Bennighof is presented in the context of improving vehicle dynamics (*i.e.*, how will a car ride with different suspension or over different terrains) and accordingly is focused on the damping problem.

It is the Examiner's burden to establish *prima fac*ie obviousness. *See, e.g., In re Rijckaert*, 9 F.3d 1531, 1532, 28 USPQ2d 1955, 1956 (Fed. Cir. 1993). Obviousness is a legal question based on underlying factual findings. *In re Gartside*, 203 F.3d 1305, 1316 (Fed. Cir. 2000). Obviousness requires a teaching that all elements of the claimed invention are found in the prior art and "a reason that would have prompted a person of ordinary skill in the relevant field to combine the elements in the way the claimed new invention does." *KSR Int'l Co. v. Teleflex Inc.*, 127 S. Ct. 1727, 1741, 82 USPQ2d 1385, 1396 (2007). As stated by the Supreme Court in *KSR*, "'***rejections on obviousness cannot be sustained by mere conclusory statements; instead, there must be some articulated reasoning with some rational underpinning to support the legal conclusion of obviousness***.'" *KSR*, 550 U.S. at ___, 82 USPQ2d at 1396, *quoting In re*

Kahn, 441 F.3d 977, 988, 78 USPQ2d 1329, 1336 (Fed. Cir. 2006)(emphasis added). The Examiner's statement of "for the purpose of determining structure" is devoid of any "articulated reasoning with some rational underpinning" and fails to discharge the Examiner's burden to set forth a *prima facie* case of obviousness under 35 U.S.C. § 103. Bennighof Thus, further to the noted evidentiary deficiencies of Bennighof that undermine the Examiner's proffered factual predicate for the asserted rejection, it is respectfully submitted that the Examiner has not provided any cogent line of reasoning to support the assertion that "it would have been obvious . . . to provide Weiss et al. with the eigenvalue sensitivity analysis and inverse method as disclosed by Bennighof for the purpose of determining structure." Withdrawal of this rejection is requested for at least the reasons presented above.

The PTO's ultimate determination of obviousness is reviewed *de novo* and *d*eterminations of the PTO are, accordingly, reviewed without deference by the courts and are upheld only where they are supported by substantial evidence. *Gartside*, 203 F.3d at 1316; *see also Dickinson v. Zurko*, 527 U.S. 150, 165 (1999); *In re Kotzab*, 217 F.3d 1365, 1369 (Fed. Cir. 2000). Substantial evidence is evidence that "a reasonable mind might accept as adequate to support a conclusion." *Id.* at 1312; *see also Consol. Edison Co. v. NLRB*, 305 U.S. 197, 229 (1938). Applicants respectfully submit that there is no substantial evidence of record to legitimize the Examiner's assertion of obviousness.

As noted above, neither Weiss nor Bennighof disclose or suggest, singly or in combination, a stiffness parameter unit for receiving said vibration information, determining natural frequency data of said structure, and determining the stiffness parameters of said structure using said natural frequency data and wherein said stiffness parameter unit comprises an iterative processing unit that determines said stiffness parameters using a first order eigenvalue sensitivity analysis and one of the generalized inverse method, gradient method, or

quasi-Newton method, wherein a number of stiffness parameters is larger than a number of system equations, as is recited in Claim 47.

Likewise, neither Weiss nor Bennighof disclose or suggest, singly or in combination, a sensor arranged to measure vibrations of said structure and output vibration information and a stiffness parameter unit for receiving said vibration information (claims 49, 60) and determining said stiffness parameters with an iterative processing unit, wherein said stiffness parameter unit comprises an iterative processing unit that determines said stiffness parameters using a first order eigenvalue sensitivity analysis, wherein a number of stiffness parameters is larger than a number of system equations (claim 49) or determining mode shape information, and determining the stiffness parameters of said structure using said mode shape information, wherein said stiffness parameter unit comprises an iterative processing unit that determines said stiffness parameters using a first order eigenvector sensitivity analysis, wherein a number of stiffness parameters is larger than a number of system equations (claim 60).

Weiss and Bennighof, whether taken singly or in combination, are respectfully submitted not to render obvious claims 47, 49 and 60 under 35 U.S.C. § 103(a) for at least the above reasons and withdrawal of this rejection is requested for at least the above reasons.

5. CONCLUSION

The Applicant respectfully submits that the claims are in a condition for allowance and action toward that end is earnestly solicited.

It is believed that no fees are presently due further to the noted one-month extension of time. However, should any fees be required (except for payment of the issue fee), the Commissioner is authorized to deduct the fees from the Nixon Peabody Deposit Account No. 50-4181 (266923-000007USPT).

Respectfully submitted,

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